CASE REPORT

ANTERIOR CRUCIATE LIGAMENT TEAR IN AN ATHLETE: DOES INCREASED HEEL LOADING CONTRIBUTE TO ACL RUPTURE?

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ABSTRACT

Rupture to the anterior cruciate ligament is a common athletic injury in American football. The lower extremity biomechanics related to increased ACL injury risk are not completely understood. However, foot landing has been purported to be a significant contributing factor to the ACL injury mechanism. In this case report, information is presented on an athlete previously tested for in-shoe loading patterns on artificial turf and subsequently went on to non-contact ACL rupture on the same surface. This case report describes the specific findings in a study participant who suffered an ACL rupture after testing and suggests that flatfoot tendency in running and cutting maneuvers might lead to an increased risk of ACL injury.

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INTRODUCTION

The mechanisms of anterior cruciate ligament (ACL) injury during competition are the subject of intense and ongoing research. Previous authors have quantified the pattern of limb kinematics as they relate to the actual ACL injury in both non-injured and ACL-injured limbs.[2-4] The pattern of in-shoe foot loading and the potential relationship to ACL injury has been theorized by Ford et al.[1] Interestingly, one of the study subjects from this prospective study sustained an ACL rupture during the subsequent competitive football season. In the current case report, in-shoe foot loading patterns are presented on athletes who sustained a subsequent non-contact ACL rupture. The subject's results of pre-participation examination are compared and contrasted to the other study subjects.

CASE DESCRIPTION

The patient had previously undergone in-shoe foot loading pattern analysis as part of a prior prospective study.[1] Prior to testing, the subjects signed an informed consent form approved by the Cincinnati Children's Hospital Institutional Review Board. Seventeen male subjects participated in the data collection *(Figure 1)*. Each subject was fitted with a football-specific molded cleat (14-stud molded Speed TD, Nike, Beaverton, OR) *(Figure 1C)* and was tested while cutting and running through a pre-set obstacle course demarcated by cones.[1-5] Flexible in-shoe pressure distribution measuring insoles were inserted in the right cleat (Pedar, Novel, Inc. St. Paul, MN) *(Figure 1A-B)*. A telemetric signal was sent from the backpack to a laptop computer to allow wireless data collection. Two digital video cameras collected simultaneously at 60 fields per second to assist in identification of the three, right foot cutting steps during data reduction *(Figure 2)*. The results were then analyzed as reported previously.[1] A regional analysis of the foot was performed utilizing nine separate "masks" consisting of medial and lateral heel, medial and lateral midfoot, medial, central and lateral forefoot, hallux, and the lesser toes *(Figure 1C)* (Groupmask Evaluation, Novel, Inc. St. Paul, MN). Regional analysis of in-shoe forces have been utilized and described in depth by several authors.[5-7] The maximum force for each region was calculated. The specific recordings from the athlete in question were compared to all other subject participants. Figure 3 depicts the distribution of the maximum ground reaction force from the plantar surface of the foot while participating in cutting maneuvers. The case patient demonstrated increased force in the medial and lateral heel, greater than one standard deviation above the mean (Figures 3-4). The load patterns noted in this patient suggest increased heel and flatfoot landing, as the pressure on the posterior aspect of the foot increased. Figure 5 represents the case patient (A) and a representative subject (B) during a cutting trial.

OUTCOME

During a football scrimmage, a 17 year-old Caucasian male football player suffered a non-contact injury to the right knee. The injury occurred while the athlete attempted to "turn the corner" on an outside sweep running play. The athlete noticed minimal discomfort at the

Figure 1. *Subjects were instrumented with a custom backpack (A) to secure the telemetry Pedar system. A pressure distribution insole (B) was inserted into each cleat. A standard football specific cleat (C) was utilized and an analysis of each region was performed.*

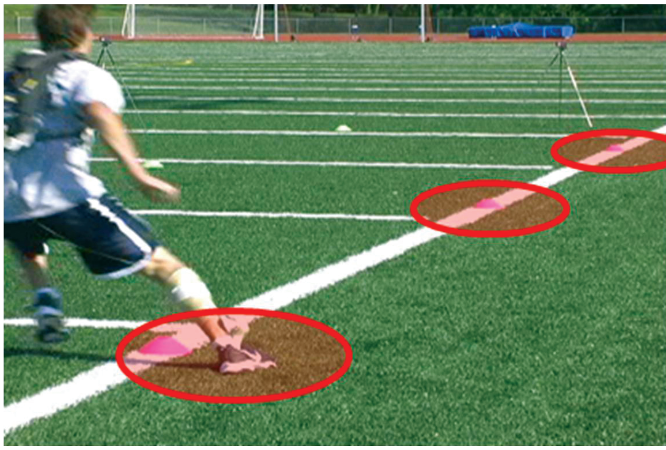

Figure 2. *A slalom course was setup on a synthetic football field and three right cutting steps were analyzed for each of the three timed trials.*

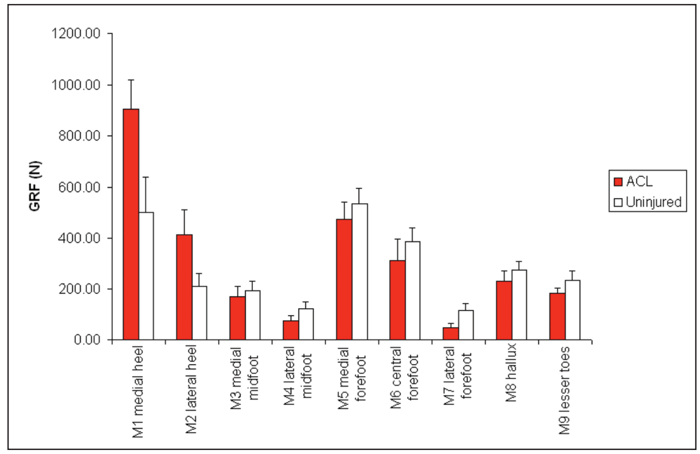

Figure 3. *Maximum ground reaction force (GRF) in Newtons (N) from each foot region. Data presented is the mean (±SD) for the control subjects and the mean (±SD) of the nine steps for the case patient.*

time, but developed increased swelling and pain in the knee, and was referred for further evaluation. On initial examination, he denied popping, clicking, or feeling of giving way of the knee. He did complain of persistent lateral-sided knee pain, but no instability. He ambulated without an assistive device four days post-injury.

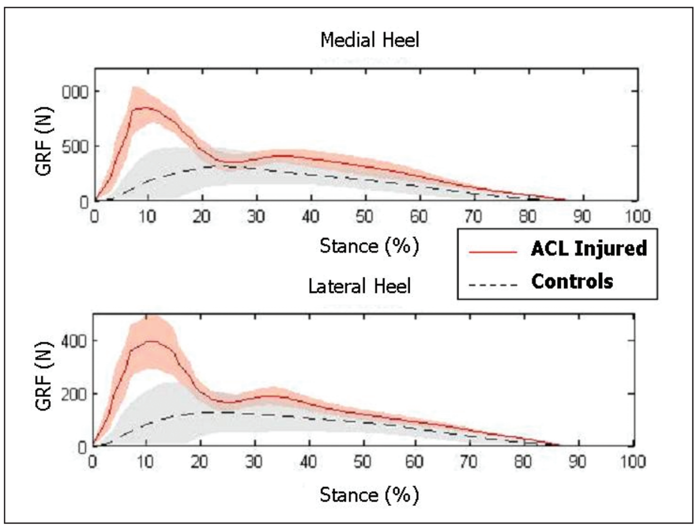

Figure 4. *Ensemble averaged (±SD) ground reaction force time normalized to the ground contact time in the medial heel and lateral heel regions of the case patient and control subjects.*

Physical examination revealed a right knee with 2+ effusion, limited range of motion from 5-100 degrees, and tenderness over the lateral joint line. Anterior drawer was positive, and Lachman testing was 1+ with a soft endpoint. Magnetic resonance imaging confirmed an ACL rupture, lateral meniscal tear, and bone contusion of the lateral tibial plateau. No varus or valgus instability was present, and external rotation-recurvatum testing was negative. Posterior drawer was negative, as well.

With the intention to return to high-level competitive football, the patient elected to undergo ACL reconstruction. Arthroscopy confirmed the ACL rupture and complex unrepairable posterolateral meniscus tear. Partial lateral meniscectomy was performed, as well as ACL reconstruction with bone-patella tendon-bone autograft from the ipsilateral knee. The patient tolerated the procedure well, and range of motion exercises were instituted early in the post-operative course. At two months his range of motion was 0-135 degrees with no pain. At 6 months post operative he returned to spring track and was pursuing a collegiate football career.

DISCUSSION

The ACL rupture is a common and intensely studied injury. Many studies have been performed that attempt to elucidate the pattern of limb movement at the time of ACL rupture. If limb kinematics in the ACL-injury prone athlete can be elucidated, perhaps prophylactic measures could be taken to reduce the risk of rupture of the ACL. However, no prospective studies of foot pressure measurements prior to ACL injury have been reported in the literature.

A number of authors have made attempts to analyze limb position at the time of ACL failure. Teitz[8] reviewed video clips of 54 athletes with ACL ruptures in an attempt to more accurately determine limb position in non-contact ACL injury. These authors noted that ACL injury tended to occur when the center of gravity was behind the knee and when ground contact with the entire foot occurred. Two-thirds of the women and all of the men in this study had a flatfoot position at the time of injury.[8]

A significant amount of foot pressure research has been dedicated to the position of the foot while participating in certain sports. Eils et al[5] noted that soccer players performing cutting maneuvers tended to load the anterior portion of the foot, implying a plantarflexed position. Ford et al[1] noted that different playing surfaces may affect the loading pattern of the cutting athlete.

Other authors have used video analysis of ACL ruptures, with mixed results. Krosshaug and Bahr[9] showed that uncalibrated video from multiple angles could be used to estimate kinematics. Boden et al[4] used video analysis and noted that initial contact of the foot in a flatfoot position might indicate a risk for ACL injury.

The shoe to surface interaction has also been studied to determine its relationship to ACL injury. Scranton et al[10] monitored non-contact ACL injuries in the National Football League over five seasons and examined the relationship of the variables of playing surface, shoe type, and playing conditions to the occurrence of these injuries. More ACL injuries occurred on natural grass than on an artificial surface. Almost half of all injuries (47.5%) occurred during game-day exposures, despite the finding that the practice versus game-day exposure rate was 5:1. Over 95% of ACL injuries occurred on a dry field.[10] Orchard and Powell[11] examined the relationship between knee and ankle sprains, playing surface, and the weather conditions on the day of the game. They reported a reduced risk of significant knee sprains on grass compared with indoor synthetic (plastic resin) turf. They found that cold weather was associated with a lower risk of significant knee sprains and ACL injuries when compared to hot weather in outdoor stadiums. The authors concluded that cold weather was associated with lower ACL injury risk in outdoor grass stadiums related to the reduced shoe-surface traction.[11] Baker et al[12] concluded from a review of the literature that no strong association exists between playing surface or footwear and ACL injury risk. Although the available data on shoe-surface interaction have not lead to a consensus on its relation to ACL injury risk, biomechanical examination of the possible mechanisms of ACL injury presented in the current football player should be studied further.

CONCLUSION

The presented case of a football athlete indicated a flatfoot landing pattern that may be associated with a non-contact ACL injury mechanism. In the study reported by Ford et al[1] only one ACL injury occurred in the tested athletes. This injury occurred in an athlete with heel to flat-foot loading more than one standard deviation above the mean. Future research should investigate the potential evidence that flatfoot tendency in running and cutting maneuvers might lead to an increased risk of ACL injury. Further studies might attempt to identify those athletes with increased flatfoot landing patterns and determine if these foot loading patterns relate to increased ACL incidence during competitive play.

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